the ad valorem tax factor.[172] However, if account balances have been overstated, as the FCC auditors allege, these cost factors and UNE prices have been lower than they would have been otherwise. Consequently, if account balances were reduced, as recommended in the audit reports, the result would be to increase these factors, and thus, there would be moderate increases in future UNE prices.[173]

Accordingly, even if account balances had been materially overstated, as alleged in the audit reports, such alleged overstatements would not have caused universal service support or UNE prices to be higher.

X. Significant Retirements May Increase the RBOCs' Depreciation Reserve Deficiencies (Issue 9(b)(2)).

The FCC has recognized the need to address the recovery of historical or embedded costs, that is, according to the FCC, "whether and to what extent carriers should receive compensation for the recovery of allocated costs of past investments if competitive market conditions prevent them from recovering such costs . . ..."[174] As the FCC has acknowledged, some of this under-recovery "may be traced to past regulatory practices"[175] such as the FCC's regulation of depreciation rates which established unreasonably long depreciation lives.[176] In the Access Reform Proceeding, in 1996, the

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[172] *Id.* at 16.

[173] *Id.*

[174] *Access Charge Reform; Price Cap Performance Review for Local Exchange Carriers; Transport Rate Restructure and Pricing; End User Common Line Charges*, 12 FCC Rcd 10175 n.25 (1997).

[175] *Access Charge Reform; Price Cap Performance Review for Local Exchange Carriers; Transport Rate Structure and Pricing and Usage of the Public Switched Network by Information Service and Internet Access Providers*, 11 FCC Rcd 21354 ¶ 249 (1996).

[176] *Id.* ¶¶ 266-270.

FCC asked ILECs to quantify their depreciation reserve deficiencies.[177] As an example of the responses the FCC received, SWBT calculated, using the procedures in the FCC's depreciation study guide, a conservative, low-end figure of $1.8 billion for its depreciation reserve deficiency (on an unseparated basis).[178] While this figure underestimated the true amount of the depreciation reserve deficiency at that time,[179] it represented the minimum amount of depreciation catch-up recovery as of 1996. The NOI asks what impact the alleged discrepancies in the CPR would have on cost recoveries of this type.

Given that the size of the discrepancies is much smaller than the audit reports allege, there should not be much, if any, change in the depreciation reserve deficiency, especially after one considers other factors affecting that deficiency over time. However, if the quantity of resulting retirements were material and if the retired assets have not been fully depreciated, then the amount of this depreciation reserve deficiency would increase because of the way it is calculated using the procedures in the FCC's depreciation study guide. The depreciation reserve deficiency is the difference between the book reserve and the theoretical reserve. Under the FCC's method of calculating this reserve deficiency, while the entire cost of the retired assets is removed from the book reserve, that cost is only removed from the theoretical reserve to the extent that the asset has been depreciated at the time of the retirement. Thus, retirements prior to fully

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[177] *Id.*

[178] Comments of Southwestern Bell Telephone Company, CC Docket No. 96-262, filed January 29, 1997, at 56-58 & Appendix 2. In its calculation of the $1.8 billion reserve deficiency, SWBT did use appropriate economic lives and net salvage parameters for each asset category consistent with SWBT's external financial reporting.

[179] *Cf.* Comments of Southwestern Bell Telephone Company, Pacific Bell and Nevada Bell, CC Docket No. 98-137, filed November 23, 1998, at 25 n.67 (providing an economic theoretical reserve deficiency of $3,987 million as of 1997).

depreciating assets would increase the difference between the book reserve and the theoretical reserve, and thus lead to a larger reserve deficiency. Other methods of calculating the depreciation reserve deficiency may avoid this impact.

XI. The FCC Should Consider this Audit in a Broader Context than the Auditors (Issue 10).

In Issue 10, the FCC recognizes that these audits need to be considered in a broader context that takes into account factors such as whether the auditors used a reasonable interpretation of the rules, whether the FCC has consistently applied these requirements, whether these requirements serve any useful purpose, whether they are consistent with other statutory and regulatory policies such as the cost benefit analysis required by Section 11 of the 1996 Act, and how they compare to the asset tracking activities of other state and federal governmental agencies such as the Federal Energy Regulatory Commission ("FERC") and the General Accounting Office ("GAO") and to the standards of GAAP required for Securities and Exchange Commission ("SEC") reporting purposes.[180] Many aspects of these broader issues are the subjects of intense debate in various Biennial Review proceedings.[181] The FCC can simply take administrative notice of the record in those proceedings and the many doubts that parties have raised regarding the validity of the original purpose of the relics of rate-of-return regulation, including the property record requirements. As price cap regulation has evolved, the FCC has endeavored to make rates less and less reliant on costs and accounting records. As discussed under Issue 8 above, the FCC has succeeded in

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[180] NOI at 4.

[181] *See, e.g.,* Arthur Anderson Whitepaper; "Supplement to July 15, 1998 Position Paper: Accounting Simplification in the Telecommunications Industry", at 11, filed with Letter dated November 10, 1998 from Mr. Carl R. Geppert, Arthur Andersen LLP to Ms. Magalie Salas, FCC ("Arthur Andersen Whitepaper Supplement").

disconnecting costs and rates to the point that the audits are not material to the price cap rate setting process. The FCC has recognized the reduced value of these requirements under price caps, and yet, its auditors began the first such comprehensive CPR audits eight years after adopting price cap regulation.

These audits were performed in a manner that unduly intensified the burden of the CPR requirements, considering their limited value. According to the rules, the CPR is supposed to include the "specific location of the property within each accounting area."[182] The accounting area is generally an entire state or group of states.[183] A central office is a "specific location" in the state. The rules do not include a definition of "location" or "specific location." Thus, by interpreting the rules to require the RBOCs to identify exactly which central office bay or frame contains an item, the auditors have applied an overly strict and narrow interpretation of the CPR requirements.[184] While the PICS/DCPR system generally identifies the floor and bay location as well as the continuing property record number, the rules do not specifically require that all of these details be included in the CPR. It should be sufficient if the CPR identifies the central office location. Thus, if an item was found anywhere within the central office, it cannot properly be deemed "not found," even if the details in the CPR do not match exactly what the auditors observed or exactly what is stated on a supporting invoice. Further, immutable conclusions reached by the auditors during their limited one-time field visits is another form of interpretative narrowing of the CPRs to include data that is not stated in

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[182] 47 C.F.R. § 32.2000(f)(5).

[183] *See, e.g., In the Matter of GTE Telephone Operating Companies; Release of Information Obtained During Joint Audit*, 13 FCC Rcd 9179, Audit Report, GTE Response at 12 (1998).

[184] *See also* GTE's Motion for a Declaratory Ruling on Asset Verification, filed May 13, 1998.

the rules. According to the auditors, the company has a limited window of ten to twenty minutes to find each randomly selected item and present convincing evidence that it is truly the same as the item listed in the CPR. All of the auditors efforts after-the-fact cannot change the fact that they reached their conclusions during or shortly after the field visits and did not seriously consider any, but the most compelling, of the RBOCs' post-field audit submissions. These audit procedures involved unprecedented interpretations of the rules and how they are to be applied generally to the industry, which interpretations the auditors did not have authority to adopt.

Moreover, increasing the burden of these regulations at this time via comprehensive audits and unprecedented interpretations by the auditors does not make sense long after abandonment of rate-of-return regulation. Further, it is inconsistent with the requirement that the FCC eliminate unnecessary regulation because the FCC does not need such detailed property records to perform its regulatory functions and it certainly does not need to interpret its requirements in such an onerous, one-sided fashion to carry out any of its responsibilities.

The CPR requirements were adopted and enhanced during the rate-of-return era, but now is the time to relax them. When a federal uniform system of accounts ("USOA") was first adopted for telephone companies in 1913, there were no property record requirements.[185] That USOA provided that the "amount charged as expense of depreciation should be based upon rules determined by the accounting company."[186] After the FCC took over the USOA, it required LECs to begin preparing a CPR in 1937

[185] Interstate Commerce Commission, Uniform System of Accounts for Telephone Companies, adopted Dec. 10, 1912.

[186] *Id.* § 23 ("Depreciation of plant and equipment.")

and initially required it to be completed by mid-year 1939.[187] This completion date subsequently slipped to mid-year 1946.[188] While the very general CPR requirement had been adopted in 1930s, specific guidelines were not added until 1943.[189] As of 1943, the guidelines required the CPR to "reveal the essential details of construction and the cost of each building, each central office in each building and each large [PBX]."[190] The entire central office was the "property record unit." While underlying records had to be maintained to enable the company to make a "reasonably accurate estimate" of the cost of individual "retirement units" within the central office "property record unit," a detailed CPR was not yet required. By 1953, the FCC had added a requirement that, in some cases, the cost of the central office property record unit be broken down into the individual retirement units of which it was composed.[191] Finally, with the advent of computerized records, AT&T submitted plans for a detailed mechanized CPR in the mid-1960s which was formally approved as to hardwire equipment in the December 1968 ruling, as explained in more detail in the SBC LECs' Response.[192] This chronology shows how the FCC gradually increased the level of detail required in the CPR over the years during which it exercised regulatory oversight over the RBOCs' rates using a cost-based, rate-of-return method that increasingly focused on more detailed accounting data.

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[187] 47 C.F.R. § 31.2-26 (1938).

[188] 47 C.F.R. § 31.2-26 (1949).

[189] *Id.* Appendix B, ¶10.

[190] *Id.* Appendix B, ¶2(c).

[191] 47 C.F.R. Part 31, Appendix B, ¶2(d)(1953).

[192] *See* SBC LECs Response at 34-38.

With these CPR audits, the auditors are continuing in the same direction by proposing to apply even stricter CPR requirements, despite the fact that the FCC changed directions ten years ago, when it began to reduce its reliance on detailed accounting data and that the FCC practically reaches its "no-reliance-on-accounting-data" destination in the *Pricing Flexibility Order*.

Recent developments at the FERC are instructive in this area. In a recently concluded rulemaking, the FERC recognized that

> [T]he level of detail prescribed by the current property unit listings and regulations place an unnecessary burden on Companies, are not current, are too restrictive, and appear to provide minimal benefit to either the Companies or to the Commission.[193]

Accordingly, the FERC

> concluded that eliminating the property unit listings and regulations would give Companies the flexibility to maintain their own property listings and track the costs of fixed assets at the level of detail tailored to their business. This in turn would reduce the burden Companies experience when tracking fixed assets at a level more detailed than either their business or the Commission needs, and also eliminate the burden placed on the Commission to update the items in the listings to take account of technological advances and items of property that are no longer used by Companies.[194]

While the companies still have to maintain a property recordkeeping system, the FERC permitted them to define their own property record units without having to seek any approval or make any filing with FERC. Thus, the FERC-regulated utilities are permitted to maintain their property records at a higher level than the individual retirement units if they so choose. Ironically, the FERC has simplified its CPR requirements even though it

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[193] Units of Property Accounting Regulations, 63 Fed. Reg. 6847 (Feb. 11, 1998).

[194] *Id.*

continues to use a rate-of-return approach in its rate-making proceedings.[195] In contrast, the FCC has abandoned rate-of-return regulation but continues to maintain overly burdensome and detailed property record requirements, despite the deregulatory mandates of the 1996 Act.

As the discussion above and under Issue 8 demonstrates, there is little, if any, benefit and significant costs in continuing to require excessively detailed CPRs. Even assuming that requiring a CPR has some valid regulatory purpose, the currently required level of detail is far more than could be reasonably necessary. ILECs should be allowed to combine two or more retirement units in the manner allowed by the FERC, i.e., without the necessity of the agency's prior approval. In fact, in the not-so-distant future, the FCC should consider relying solely on the requirements of GAAP so that ILECs are not placed at a disadvantage compared to their competitors who are not subject to such onerous, costly requirements.

GAAP provides a sufficient safeguard for SEC purposes and it should also be sufficient for FCC purposes, in view of the minimal practical utility of these CPR requirements. Property records are useful as part of the internal controls necessary to safeguard assets and ensure that financial statements and account balances are accurately stated, but there is no added value in requiring more detail than what is necessary to satisfy GAAP and the needs of the business to manage assets efficiently.[196] While GAAP is generally silent as to precisely which mechanisms are necessary to assure accurate financial reporting of asset account balances, it does require adequate internal controls designed to satisfy the concepts of GAAP, such as representational faithfulness, which

[195] *Maine Public Serv. Co.*, 85 F.E.R.C. 61,412 (1998); *South Carolina Elec. & Gas Co.*, 76 F.E.R.C. 61,338 (1996).

[196] In addition, the Foreign Corrupt Practices Act requires publicly held companies to have adequate internal accounting controls over all assets. *See* 15 U.S.C. § 78m.

refers to the correspondence or agreement between the accounting numbers and the resources or events those numbers purport to represent.

The NOI inquires "what other federal and state agencies do . . . to ensure the accuracy of books and records."[197] Aside from the recent developments at the FERC, the experience of the federal government itself provides an interesting contrast to the FCC auditors' activity. In the 1997 Consolidated Financial Statement for the United States Government, the GAO describes the following "material deficiency" in the government's recordkeeping:

> Hundreds of billions of dollars of the more than $1.2 trillion of these reported assets are not adequately supported by financial and/or logistical records. . . .
>
> Because the government does not have complete and reliable information to support its asset holdings, <u>it could not satisfactorily verify the existence of all reported assets</u>, substantiate the amounts at which they were valued, or determine whether all of its assets were included in its financial statements. . . . These problems impair the government's ability to (1) know the location and condition of all its assets, including those used for military deployment, (2) safeguard them from physical deterioration, theft, or loss, (3) prevent unnecessary storage and maintenance costs or purchase of assets already on hand, and (4) determine the full costs of government programs that use the assets.[198]

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[197] NOI at 4.

[198] GAO, Report to the Congress, Financial Audit: 1997 Consolidated Financial Statements of the United States Government at 16-17 (Mar. 1998)(emphasis added). *Accord*, GAO, Report to the Congress, Financial Audit: 1998 Financial Report of the United States Government at 19, 23 (Mar. 1999) ("Major problems included the federal government's inability to . . . properly account for and report . . . billions of dollars of property, equipment, materials, and supplies. . . . The federal government . . . does not have adequate systems and controls to ensure the accuracy of information about the amount of assets held . . .. A majority of the $466 billion of these reported assets is not adequately supported by financial and/or logistical records. . . . Also, the government cannot ensure that all assets are reported. . . . [P]eriodic physical counts have shown that property records contain significant error rates.").

The SBC LECs are not suggesting that the Government should spend excessive amounts of taxpayer money to create onerous property recordkeeping systems like those that apply to LECs or to otherwise adopt overly stringent controls over assets. However, it is ironic that the RBOCs are being held to such high, intricately detailed CPR standards when the government itself cannot satisfy the basic requirements of the applicable accounting principles.[199] At a minimum, the same sort of cost benefit approach that is applied on a national scale or by other federal agencies should be generally instructive for the FCC's approach to the private sector.

Conclusion

For the foregoing reasons, the FCC should reject the audit results as unsound and unreliable. The audits were not designed or performed in a manner that could enable the auditors to achieve their objectives. The serious deficiencies in the sample design and the auditors' procedures prevent the audits from serving as the basis for any corrective action. The auditors' three recommendations – for write-offs, complete physical inventories and independent reviews of internal controls – are not justified by the flawed audit results. Even if these significant flaws could be corrected after the fact, the recommendations would not be justified when one applies a cost/benefit analysis. In fact, these recommendations are contrary to the rules and the record in several respects. Besides, the auditors have ignored significant information presented by the RBOCs in reaching their conclusions, including most importantly, their rejection, without explanation or further investigation, of the RBOCs' proof of the existence of dozens of the items scored as "not found." In any event, even assuming the validity of some of the audit results, they should not play any role in the performance of any of the FCC's regulatory functions, such as ratemaking, universal service support calculations or UNE

[199] The federal government's financial statements are governed by the Statements of Federal Financial Accounting Standards ("SFFAS").

pricing. Instead of taking any action, such as that recommended by the auditors, based on these audits, the FCC should consider methods of streamlining and updating the FCC's asset tracking requirements to require no more than what is reasonably necessary.

Respectfully submitted,

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September 23, 1999

Review of the Pacific Bell and Nevada Bell CPR Statistical Audit Plan

Ernst and Young has been retained by Southwestern Bell Telephone Company, Pacific Bell and Nevada Bell (the "SBC BOCs") to review the FCC's draft audit reports of the continuing property records of the BOCs on their behalf. E&Y was to identify significant errors and omissions from a statistical and processing standpoint, subject to the Nondisclosure Commitment dated July 20, 1998.

This report provides details of E&Y's findings in its analysis of the sampling plan used by the FCC for the Current Property Records (CPR) audit of Pacific Bell and Nevada Bell Telephone Companies – the Pacific Telesis group henceforth referred to as Pacific. Specifically, there is a discussion of four issues:

- an inappropriate choice of sample design;
- the incorrect calculation of margins of error;
- many sources of bias that affect the estimates; and
- the lack of a two-way audit.

After discussing each of the above issues, we provide a comparison of calculations we have made with those published in the FCC's draft report. We conclude that the FCC's estimates contain biases and are inaccurate. Given these deficiencies, we believe the amounts reported by the FCC as overstated investment are unsound and cannot be fairly relied upon. To set the tone for these discussions, we first provide some definitions and describe the notation that will be used in the equations that will follow.

Definitions and Notation

- The population of interest is the central office hardwire records of the current property record (CPR) database of Pacific as of June and July 1997.

  Denote the total number of such records in this population by M_0.

- We shall refer to a record in the CPR database as a line item.
- A central office location is denoted by the first eight characters of the Common Language Location Indicator (CLLI). We will henceforth refer to each central office location as a CLLI.
- For the audit, CLLIs are divided into L groups or strata.
- A line item belongs to one, and only one CLLI.

- For each $h = 1,\ldots,L$ of the CLLI strata, let

  N_h = the number of CLLIs in stratum h,

  n_h = the number of CLLIs selected for the audit in a sample from stratum h,

  M_h = the total number of line items across all CLLIs in stratum h,

  M'_h = the total number of line items in all CLLIs selected for the audit within stratum h, and

  m_h = the total number of line items selected for the audit in stratum h.

  Note that $$M_0 = \sum_{h=1}^{L} M_h .$$

- Within stratum h ($h = 1,\ldots,L$), let

  M_{hi} = the number of records in CLLI i ($i = 1,\ldots,N_h$) of stratum h, and

  36 = the number of FCC sampled line items in the selected CLLI of stratum h.

  Note that $$M_h = \sum_{i=1}^{N_h} M_{hi} ,$$

  $$M'_h = \sum_{i=1}^{n_h} M_{hi} \text{ , and}$$

  $$m_h = 36 \cdot n_h .$$

- Within CLLI i ($i = 1,\ldots,N_h$ when referring to the whole population, or $i = 1,\ldots,n_h$ when referring to the sample of locations for the audit) of stratum h ($h = 1,\ldots,L$), let

  y_{hij} denote the observed value for line item j ($j = 1,\ldots,M_{hi}$ for the population of line items, but $j = 1,\ldots,36$ for line items chosen for the audit) within CLLI i of stratum h. For example: if you are interested in the number of compliant line items, then y_{hij} is either 0 or 1 when a line item is either non-compliant or compliant; or if you are interested in the total in-place cost for line items that can't be located, then y_{hij} is the in-place cost of a line item that cannot be located, and zero otherwise.

Sample Design Considerations

A sample design is the plan for choosing items for a sample. According to the draft report, the CPR hardwire audit conducted by the FCC used a two-stage, stratified cluster design. This was accomplished via the following steps:

1. The total number of hardwire line items for the audit sample was determined to be 1082.
    - The methodology for determining this assumed a simple random sample would be taken at both stages.
    - The criterion for determining the sample size was a desire to have a margin of error for the proportion of compliant line items of at most 0.025.
    - It appears to have been implicitly assumed that the degrees of freedom of the estimator would be large enough to use normal distribution theory.
2. It was determined that auditors would try to find the property corresponding to 36 randomly chosen line items within each randomly selected central office location.
3. The number of central office locations needed for the audit was determined to be 30, the result of dividing 1082 by 36 and truncating to an integer.
4. The sampling frame was determined as follows.[1]
    - All line items were clustered within locations that were determined by eight character CLLI codes.
    - After removing non-hardwire records, line item counts were done for each CLLI.
    - CLLIs with fewer than 100 line items were discarded and the remaining CLLIs were considered to be central offices.
5. The CLLIs in the frame were divided into 11 strata based on the number of line items.
6. The sample size of 30 CLLIs was allocated across the strata proportionately to the total number of records in each stratum.[2] After adjusting the resulting number to be integers that added up to thirty, any stratum that was allocated fewer than two CLLI selections had its allocation increased to two.[3] This increased the total number of CLLIs in the sample to 34. In turn, this increased the total number of line items for the audit to $34 \cdot 36 = 1{,}224$.
7. Within each stratum, CLLIs were randomly selected according to the allocation plan in step 6.

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[1] This is not described in the draft report. This procedure was described by the FCC staff to SBC, and subsequently relayed to us.

[2] The draft report states that Neyman allocation was used. It does not state what was used as each stratum's variance, S^2_h. We suspect that the variance of the proportion of all compliant line items in the stratum was used with the proportion set at 0.5. If so, the variances are treated as being the same across all strata, and the allocation becomes proportionate to record counts. Our own calculations using proportionate record counts allocation produce results which are consistent with those published in the summary table on page 7 of the draft report's Appendix B.

[3] See footnote 17 of Appendix B in the FCC's July 20, 1998 draft report (concerning advice from Census Bureau staff), and discussions with SBC personnel, we believe that the increase to 2 locations in a stratum was done after many of the first 30 locations had been visited.

8. For each CLLI selected in step 7, thirty-six line items were randomly selected for the audit.[4]

While this sample design can be used to calculate estimates of many different population quantities, most estimates produced from it will not have very good precision. Major decisions for the design were based on the desire for a precise estimate of the proportion of compliant records. These included:

- determining the total number of line items for the audit;
- allocation of the total number of CLLIs across strata; and to some extent,
- the division of CLLIs into strata.

Even at that, the sample design does not produce the desired effect – a margin of error of at most 0.25 for the estimate of the proportion of compliant line items. This is due to the fact that the effect of clustering – sampling line items within a CLLI – was not taken into account at the design stage. Instead methods based on simple random sampling were used – even though the design is more complex than a simple random sample. For an account of how to design a complex sample so that a planned precision can be approximately achieved see Chapter 8 of Kish.[5]

Furthermore, if a precise estimate of the total in-place cost associated with non-locatable line items is desired, then the sample design should take this into account. Selecting CLLIs proportional to the total in-place cost of each CLLI, and stratification based on in-place cost are two concepts that may help reduce the variance of in-place cost related estimators. For more on audit sampling issues, see "Statistical Models and Analysis in Auditing."[6]

As a general rule, the precision of dollar value estimators is much more sensitive to design decisions than are proportion estimators. By this we mean that a design made for a precise dollar estimator will most likely produce a proportion estimate with acceptable precision. The reverse of this is seldom true. Additionally, more CLLIs need to be selected in order to use normal approximation theory. This issue will be discussed more fully in the next section.

Finally, if the FCC wanted to make conclusions about California and Nevada separately, then they are using the wrong approach. The FCC design does not support state-by-state estimation as presently structured.

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[4] From footnote 18 of the draft report Appendix B, we know that when the audit team arrived at the central office location, if it was determined that the property associated with a line item was "too hard-to-get-to," another line item was substituted. This line item was the one that preceded the randomly selected item in the CPR listing. This has the potential to introduce bias into estimates.

[5] Kish, L. (1965). *Survey Sampling*. John Wiley & Sons, New York.

[6] National Academy of Sciences, Panel on Nonstandard Mixtures of Distributions (1989). Statistical Models and Analysis in Auditing. *Statistical Science*, **4**, No. 1, pp. 2-33.

Instead of taking the FCC's approach, a state stratification should have been done. The whole CLLI sample size would then have been allocated according to a two-way stratification (by state and with the original strata). Just as with the single stratification, every stratum would need at least two CLLIs allocated to it. A minimum of two CLLIs are needed to calculate the variance. More than this minimum may be needed to obtain adequate precision for a particular state. Since this was not done, the FCC will not be able to produce precise estimates at the state level, even though they made sure that every state was represented in the sample. The sample that the FCC has drawn is not representative by state.

Margin of Error

The margin of error is a measure of the precision of an estimator. It is usually the plus/minus part of a confidence interval of the form:

$$\tilde{X} \pm t \cdot s(\tilde{X}),$$

where $\tilde{X}$ is an estimator of some population quantity X, e.g., the total number of compliant line items in the CPR, or the total in-place cost associated with missing property. The quantity $s(\tilde{X})$ is the standard error of the estimator, and t is a multiplying factor that is determined by the distribution of the standardized quantity

$$\frac{\tilde{X} - X}{s(\tilde{X})},$$

and the confidence that one wants to have in the estimate. Typically, t is a percentile of the standard normal distribution or Student's t distribution. Most basic statistics books have tables for finding these values. Statistical software and spreadsheet programs can also be used.

Following the discussion in Cochran,[7] if $\tilde{X}$ has a normal distribution with mean X, and $s(\tilde{X})$ is well determined, then t comes from the standard normal distribution. These are two very important assumptions, and if they are not true, other types of error bounds need to be calculated using more advanced techniques.

The more well known situation occurs when $\tilde{X}$ has a normal distribution, but the sample size is not large enough for $s(\tilde{X})$ to be well determined. In this case, the degrees of freedom need to be considered, and Student's t distribution is used to find the multiplying factor.

[7] See Cochran, W. G. (1967). *Sampling Techniques*, 3rd ed. Wiley, New York. Pp. 95 -96.

In a situation where stratification has been used, one needs to consider the degrees of freedom provided by each stratum. The distribution of $s(\tilde{X})$ is in general too complicated to simply compute the degrees of freedom for each stratum in the usual way – taking the CLLI sample size within the stratum minus one, i.e., (n_h - 1) – and then add them up across all strata. An approximate method of assigning an effective number of degrees of freedom to $s(\tilde{X})$ has been worked out by Satterthwaite.[8]

Let $v(\tilde{X})$ be the total variance of the estimator, and $v_h(\tilde{X})$ the component of $v(\tilde{X})$ from stratum h. Then the effective degrees of freedom can be approximated as

$$n_e = \frac{\{v(\tilde{X})\}^2}{\sum_h \frac{\{v_h(\tilde{X})\}^2}{n_h - 1}}.$$

The value of n_e always lies between the smallest of the values (n_h - 1) and their sum. For the audit described in the draft report, this value will lie between 1 and 23. Such values are too small for the normal distribution to be used.

Why is it that the central limit theorem does not apply when there is a relatively large total sample size of line items (1,224)? This is due to the two-stage design. The variance between CLLIs contributes much more towards total variance than the variances within CLLIs. Thus, the number of locations chosen plays an important role, and this number was chosen to be relatively small in the FCC sample design.

In the calculation section below, we show that the effective degrees of freedom is in the range 2 to 11, depending on the estimation method used and the scoring of the property records audited.

The draft report uses the multiplying factor 1.96, obtained from the standard normal distribution for a 95 percent two-sided confidence level. The table below shows the multiplying factor associated with different confidence levels from Student's t distribution with different degrees of freedom.

[8] Satterthwaite, F. E. (1946). An approximate distribution of estimates of variance components. *Biometrics*, **2**, pp. 110-114.

Degrees of Freedom n_e	One Sided Confidence Bounds		Two Sided Confidence bounds	
	95%	99%	95%	99%
2	2.920	6.965	4.303	9.925
5	2.015	3.365	2.571	4.032
8	1.860	2.896	2.306	3.355
11	1.796	2.718	2.201	3.106

Notice that the multiplying factors for two-sided bounds at 95 percent confidence are larger than the value from the normal distribution – namely, 1.96. Thus, the reported margin of error for all estimates in the draft report needs to be increased.

The above analysis is only useful if the underlying distribution of the estimator is normally distributed. The estimator of the proportion of compliant records would certainly be normally distributed under this design – although this should be confirmed. On the other hand, normality might not hold true for estimators associated with dollar values. Very often the dollar values of a collection of items, such as the property records, are highly skewed, i.e., there is a relatively large number of small valued items, and a relatively small number of extremely large valued items. The distribution of an estimator based on a small sample size from such a population is usually skewed as well. Hence, it is not normal.

To learn more about the distribution of an estimator for dollar values, we conducted a simulation experiment that estimated the total in-place cost of the Pacific hardwire line item population under study. This was done as follows:

1. Define a frame of CLLIs for which the total number of line items, and the total in-place cost is known. The frame should be divided into 11 strata just like the frame the FCC used for sampling. We were unable to create a sampling frame that produced a summary table exactly the same as that given in Appendix B, page 7, of the draft report. For a summary of the frame we did use, and how it compares to the frame used by the FCC for the audits, see Table 1 at the end of this appendix. In our view the two are reasonably close.
2. Randomly select n_h out of the N_h CLLIs within each stratum, and record C_{hi}, the total in-place cost for selected CLLI i in stratum h.
3. Estimate the total in-place cost using

$$\hat{C}_R = \sum_{h=1}^{L} \frac{M_h}{M'_h} \sum_{i=1}^{n_h} C_{hi} \text{ .}^9$$

[9] This estimator and the mean squared error equation that follows are equivalent, at the CLLI level, to the ones the FCC published in Appendix B of the draft audit report. See the next section for a full description of the estimator.

4. Estimate the mean squared error of $\hat{C}_R$ using

$$v(\hat{C}_R) = \sum_{h=1}^{L} \left(\frac{N_h^2(1-f_{1h})}{n_h} \cdot \frac{\sum_{i=1}^{n_h} M_{hi}^2 \left(\bar{c}_{hi} - \hat{\bar{\bar{C}}}_{Rh} \right)^2}{n_h - 1} \right), \text{ where}$$

$$\bar{c}_{hi} = \frac{1}{M_{hi}} C_{hi}$$

$$\hat{\bar{\bar{C}}}_{Rh} = \frac{1}{M'_h} \sum_{i=1}^{n_h} C_{hi}, \text{ and}$$

$$f_{1h} = \frac{n_h}{N_h}.$$

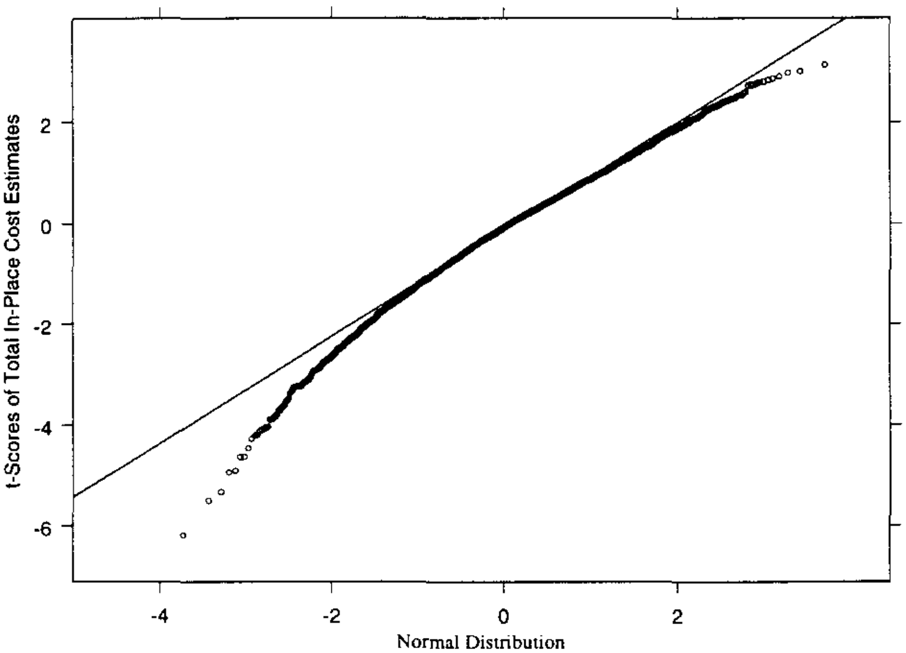
5. Calculate a t-score for the estimate, i.e., find the error in each estimate, $\hat{C}_R$ - C, where C is the known total in-place cost, and divide the error by $\sqrt{v(\hat{C}_R)}$.
6. Repeat steps 2 through 5 a large number of times. In our case we did 5,000 runs.

While this simulation does not perform an evaluation of the exact estimator the FCC used to estimate values the audit was interested in, it does provide information about how well the type of estimator that was used performs in estimating the in-place cost associated with non-locatable line items. This is because the simulation looks at estimates of a similar quantity, total in-place cost.

The simulation results give us an indication of how to proceed with determining a one-sided lower confidence bound by examining the distribution of the 5,000 realizations of the t-scores. We first compare the t-score distribution with a normal distribution via a normal q-q plot. This plot provides a powerful, visual comparison of the estimated quantiles of the t-scores with the same quantiles of a standard normal distribution. If the t-scores come from a normal (or nearly normal) distribution, then the resulting plot should look like a straight line. We follow Cleveland's[10] method of presentation where a reference line passing through upper and lower quartiles is "superposed" on the graph.

[10] Cleveland, W. S. (1993) *Visualizing Data.* Hobart Press, Summit, New Jersey.

Normal Q-Q Plot for t-Scores of $\hat{C}_R$



This plot tells us that the lower (left) tail of the distribution is much heavier than that of a normal distribution – much like Student's t distribution. However the upper (right) tail is slightly thinner than that of a normal distribution.

To find multipliers for the root mean squared error so that we can obtain one-sided lower confidence bounds, we can use the 1 percent or 5 percent quantiles of the t-score distribution. These are presented below.

Item	1%	5%
t-score	-3.177	-2.101

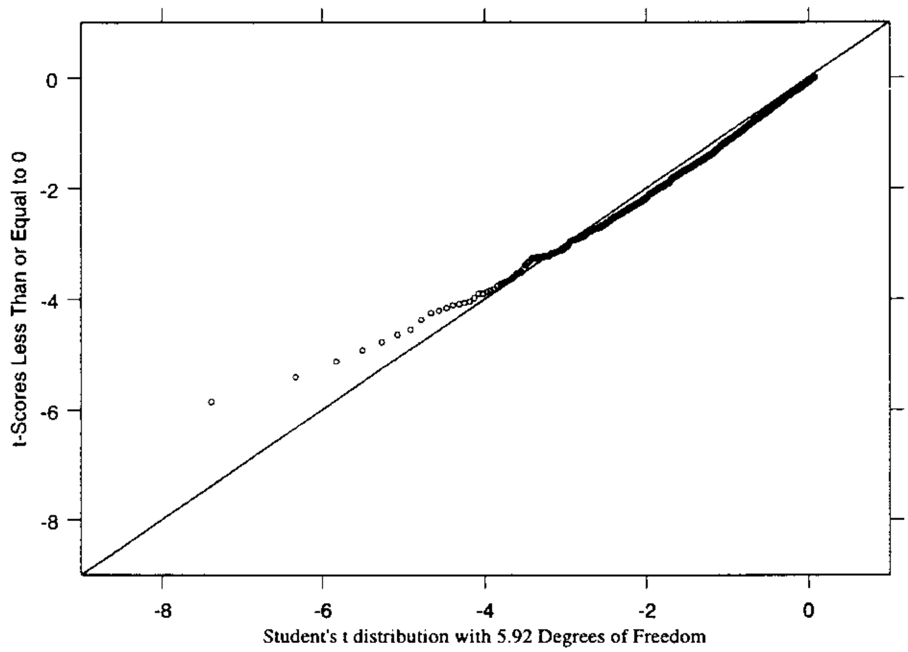
We can also use the results to answer the following questions.

1. Can Student's t distribution be used to find the multiplying factor for determining a lower confidence bound?
2. Is the Satterthwaite approximation for the effective degrees of freedom good?

To answer the first question, we proceeded by first identifying the degrees of freedom for a Student's t distribution that fit the lower tail of the t-score distribution. This was done by finding a least squares fit between the quantiles of the t-scores and a t distribution. We found that a t distribution with 5.92 degrees of freedom provides a least squares fit. To evaluate this fit, we compared the quantiles of the t-scores with those of a t distribution via the q-q plot shown below.

The fit does not appear to be very good, especially in the extreme region of the lower tail. Thus, we conclude that Student's t distribution is not adequate for finding the margin of error.

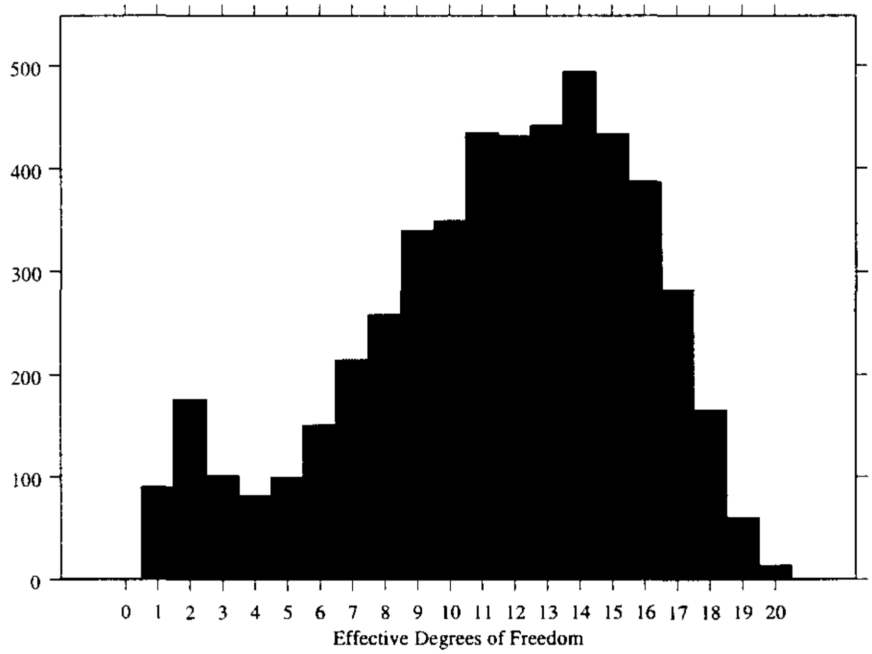
Student's t Q-Q Plot for t-Scores of $\hat{C}_R$



Even though it appears that the t distribution should not be used, it is still useful to examine the Satterthwaite approximation, since we will still rely on it for the margin of error associated with proportion estimates.

To determine how well the approximation performs, we calculated the effective degrees of freedom for each of the 5,000 realizations of $\hat{C}_R$. The distribution is very wide, and possibly bimodal (one mode around 2 the other around 14). The overall distribution has a mean of 11.4 with a standard deviation of 4.3. Thus, the Satterthwaite effective degrees varies quite a bit from sample to sample, and may not capture the true nature of the distribution that determines the multiplying factor for a margin of error.

Histogram of 5,000 Realizations of the Effective Degrees of Freedom



In light of the simulation results, we computed lower bounds for the FCC's biased estimates of dollar values using the appropriate quantile of the t-score distribution given above, e.g., a t value of -3.177 for the 99 percent lower bound. We do not know if this analysis is compatible with proportion estimation.

More advanced techniques such as balanced repeated replication, or the jackknife can also be used to determine error bounds in these more complex situations.[11] We will not go into these methods here, since we believe our point about the increase in the size of the margin of error has been made.

Once a correct approach is found for calculating error bounds, we would argue that a one-sided lower confidence bound should be used as the value assessed to be in error, e.g., the total in-place cost of non-locatable line items, or the proportion of non-compliant records. This is because only values smaller than the lower bound are, statistically speaking, significantly different from values above the lower bound The IRS uses such a rule for its audit findings.[12]

Also, if one is going to take a conservative approach, the confidence level for this bound should be set at 99 percent. This practice attempts to take into account the uncertainty

[11] See Cochran, chapter 11, sections 18 - 20. See also, Wolter, K. M. (1985). *Introduction to Variance Estimation*. Springer-Verlag, New York.

[12] The IRS uses a lower bound approach in their audit findings. In fact, the IRS calculates estimates in three ways. The method that produces the smallest margin of error is used, and the 95 percent lower bound of the method chosen is the amount assessed.

caused by various unquantifiable errors introduced into both the sampling and audit processes. In other words, as far as the FCC estimates of dollar values are concerned, use of a 99 percent lower bound of the proper confidence interval would be the prudent approach.

Given the errors discussed above and the biases to be discussed below, the amounts reported by the FCC as overstated investment are unsound and cannot be fairly relied upon. Our professional opinion is that the FCC's estimates are inaccurate.

Sources of Bias that Affect the Estimates

Several forms of bias are present in the estimates supplied in the draft report. These include:

- the use of a statistically biased estimator,
- bias caused by substituting CLLIs and line items for undesirable ones that turned up in the sample, and
- biases induced by weaknesses in audit controls.

The effect of each of these biases varies in its degree of severity. The total effect may be significant; it certainly brings up legitimate concerns for the accuracy of the audit results. We address each in turn below.

Estimator Bias

The estimator used by the FCC is statistically biased. The FCC estimator can be useful in many situations, since it may have a smaller mean squared error than the standard unbiased estimator. The formula for this FCC estimator of a total population value is given by

$$\hat{Y}_R = \sum_{h=1}^{L} \frac{M_h}{M'_h} \sum_{i=1}^{n_h} \frac{M_{hi}}{36} \sum_{j=1}^{36} y_{hij} = \sum_{h=1}^{L} \frac{M_h}{M'_h} \sum_{i=1}^{n_h} M_{hi} \bar{y}_{hi} = \sum_{h=1}^{L} \hat{Y}_{Rh}, \text{ where}$$

$$\hat{Y}_{Rh} = \frac{M_h}{M'_h} \sum_{i=1}^{n_h} M_{hi} \bar{y}_{hi}, \text{ and}$$

$$\bar{y}_{hi} = \frac{1}{36} \sum_{j=1}^{36} y_{hij}.$$

If y_{hij} is the in-place cost of an audited line item that was not located and zero otherwise, then $\hat{Y}_R$ is an estimator for the total in-place cost of non-locatable line items. On the other hand, if y_{hij} is one or zero depending on whether or not an audited line item is or is not compliant, then $\hat{Y}_R$ is an estimator for the total number of compliant line items in the population. If this is divided by M_0 then we have an estimator for the proportion of compliant line items in the population.

In order to judge the precision of an estimator, statisticians usually look at the variance of the estimator, or its square root – the standard error of the estimator. For a biased estimate, the variance does not capture the precision of the estimator with respect to the true value of the population that is being estimated. The more appropriate measure is the mean squared error of the estimator, and its square root – referred to as the root mean squared error.

An approximate sample estimate for the mean squared error for this estimator is given by

$$v(\hat{Y}_R) = \sum_{h=1}^{L} \left(\frac{N_h^2(1-f_{1h})}{n_h} \cdot \frac{\sum_{i=1}^{n_h} M_{hi}^2 \left(\bar{y}_{hi} - \hat{\bar{\bar{Y}}}_{Rh} \right)^2}{n_h - 1} + \frac{N_h}{n_h} \sum_{i=1}^{n_h} \frac{M_{hi}^2 (1 - f_{2hi}) s_{2hi}^2}{36} \right), \text{ where}$$

$$\hat{\bar{\bar{Y}}}_{Rh} = \frac{\hat{Y}_{Rh}}{M_h},$$

$$f_{1h} = \frac{n_h}{N_h}, \quad f_{2hi} = \frac{36}{M_{hi}} \text{ and}$$

$$s_{2hi}^2 = \frac{1}{35} \sum_{j=1}^{36} \left(y_{hij} - \bar{y}_{hi} \right)^2.$$

This approximation depends on how well the ratio $\frac{M_h}{M'_h}$ approximates the ratio $\frac{N_h}{n_h}$ for each $h = 1,\ldots,L$. This will depend on how much the M_{hi} vary within each stratum, and by how large n_h is for each stratum. If these ratio approximations are not good, then this formula produces a significantly biased estimate of the mean squared error. We can compare these numbers across all strata by looking at the total squared difference between the two. The square root of this total is the Euclidean distance between the two vectors, so this gives us a way to measure the closeness of the ratios across strata. The table below gives results.

Stratum h	$\frac{M_h}{M'_h}$	$\frac{N_h}{n_h}$	Squared Error
1	5.21	5.00	0.04
2	10.26	9.60	0.43
3	11.68	11.00	0.46
4	13.50	13.00	0.25
5	12.04	12.50	0.21
6	14.77	14.50	0.08
7	19.26	20.50	1.54
8	25.62	26.00	0.15
9	25.14	26.00	0.73
10	32.67	38.50	33.98
11	117.00	132.50	240.15
Total			278.02

Most of the total squared difference comes from stratum 11. So one should question the approximation for the mean squared error of the biased estimator, $v(\hat{Y}_R)$. However, this is not an extremely large total, so the overall approximation may not be all that bad.

To further evaluate the statistical bias, we can use the results of the simulation described in the previous section. For evaluating the bias of $\hat{C}_R$, we compared the average of the 5,000 realizations with the known value of the total in-place cost.

Item	Dollar Value
Total Hardwire In-place Cost[13]	4,752,507,577
Average value of $\hat{C}_R$	4,741,494,667
Standard Error of the Average of $\hat{C}_R$	4,713,143
Estimated Bias	-11,012,910
Bias as a Percentage of the Total	-0.23%

These results indicate that the bias of the estimator $\hat{C}_R$ may not be that bad. The mean value of the estimator is approximately two-tenths of a percent below the actual total hardwire investment.

To evaluate the estimator bias in the approximation of the mean squared error of $\hat{C}_R$, we first estimated the mean squared error in the following way:

1. For each of the 5,000 realizations of $\hat{C}_R$, subtract the true total in-place cost from the estimate.
2. Square each of these errors.

[13] This is the total hardwire investment in the frame used for the simulation.